Microturbines

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Microturbine Advantages

- Clean electricity
- Very low emissions
- Quiet operation
- Low maintenance
- Long engine life
- High system efficiency
- Multi-fuel operation
- Cogeneration heat

Why a Microturbine?

- Low life cycle cost
  - Competitive first cost
  - Low operating costs
  - Low maintenance
  - Longer life
- Low emissions
  - Compared to piston engines
  - Comparable to fuel cells?
- Readily adaptable to many CHP applications
  - Domestic hot water
  - Space heating
  - Absorption cooling
  - Desiccant dehumidification

Example Microturbine Specifications

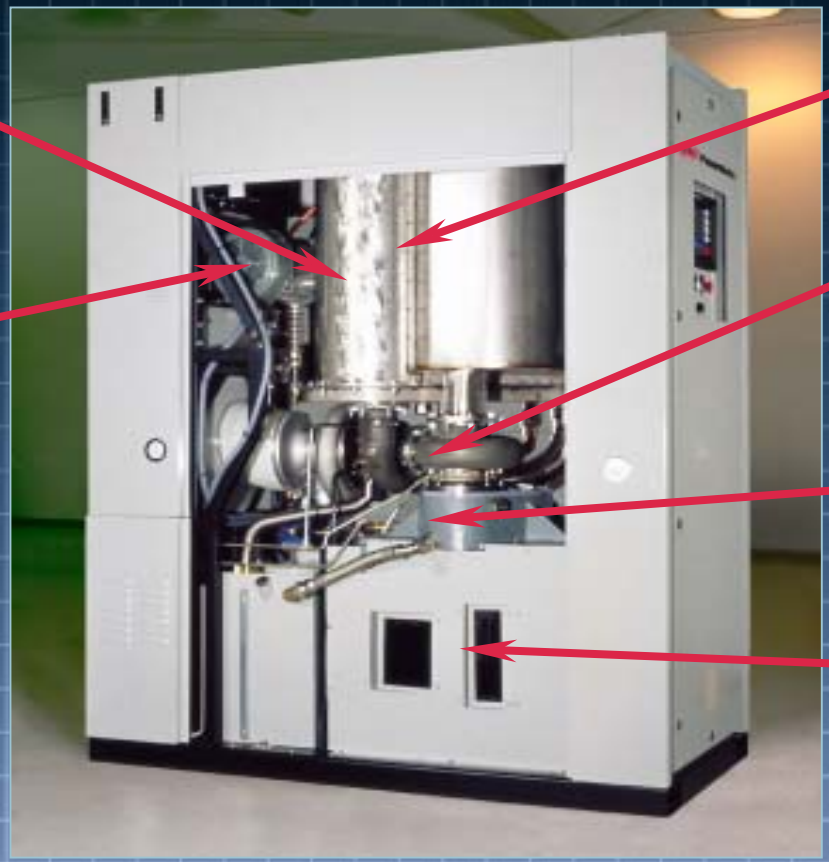
- 70kWe model
- Has 130% peaking power capacity on cold days (92 kWe)
- High efficiency
  - 29% LHV electric (28% w/booster)
  - Up to 70% total with cogeneration
- Low emissions with natural gas
  - <9 ppmv NOx @ 15% excess O_2 (typically 4-5 ppm)
- 8,000 hour maintenance interval
- 80,000 hour engine life

Example Microturbine Features

Patented Combustor
- Dry Low NOx
- Exceeds current stringent environmental regulations

Fuel Gas Booster
- Long-life
- Fully integrated
- IR technology already used in thousands of critical industrial applications

Integrated Heat Recovery
- Small footprint
- Controllable output level)



Patented Recuperator
- Essential to high efficiency
- Military grade
- Designed for 80,000 hour life

Two-Shaft Engine
- Reduces stress for longer life

Mechanical Shaft Output
- High efficiency platform

Proven Generator Technology
- Well understood by utilities
- Same technology used by utilities to power the grid

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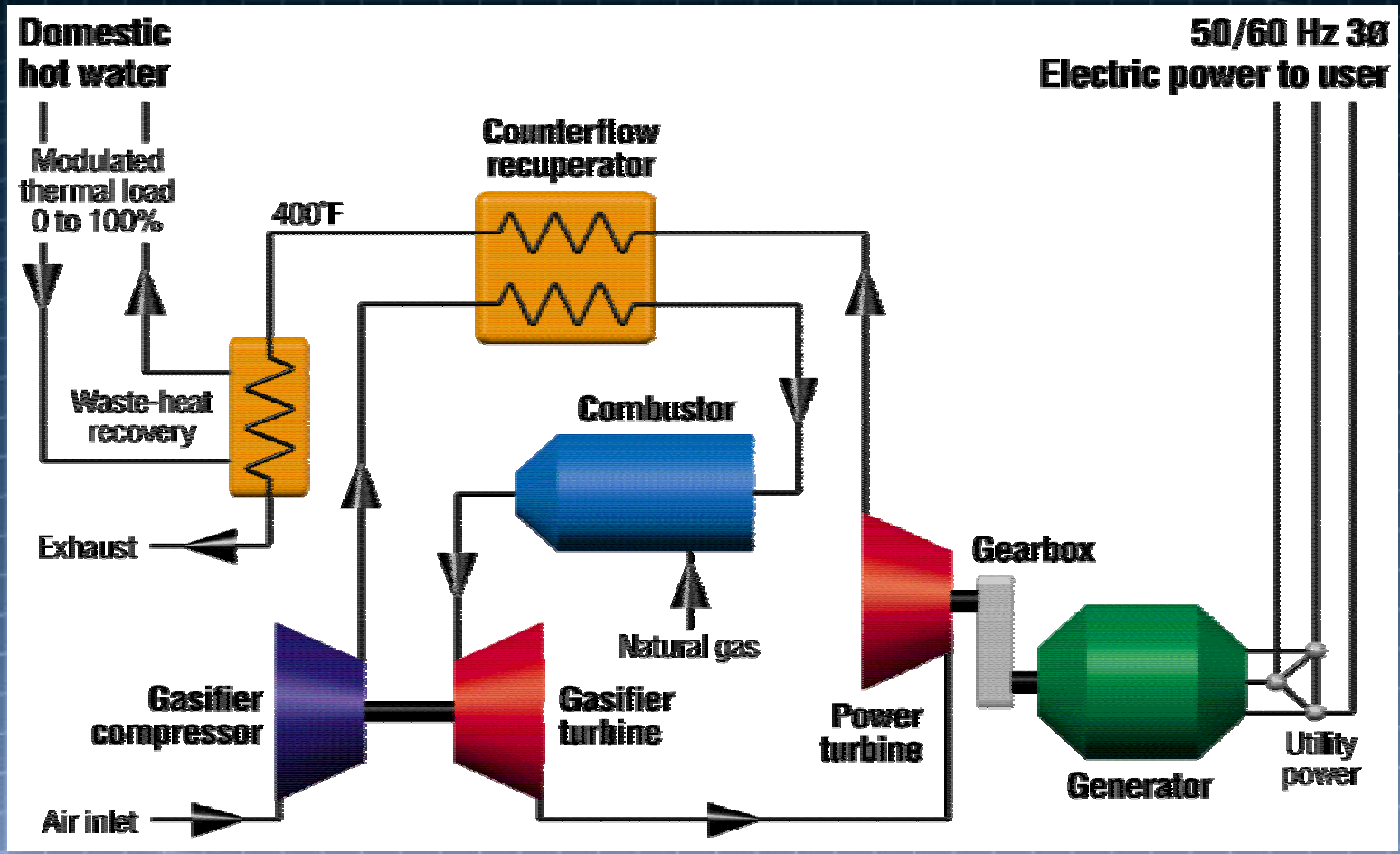
System Cycle Diagram



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Codes Used in Design

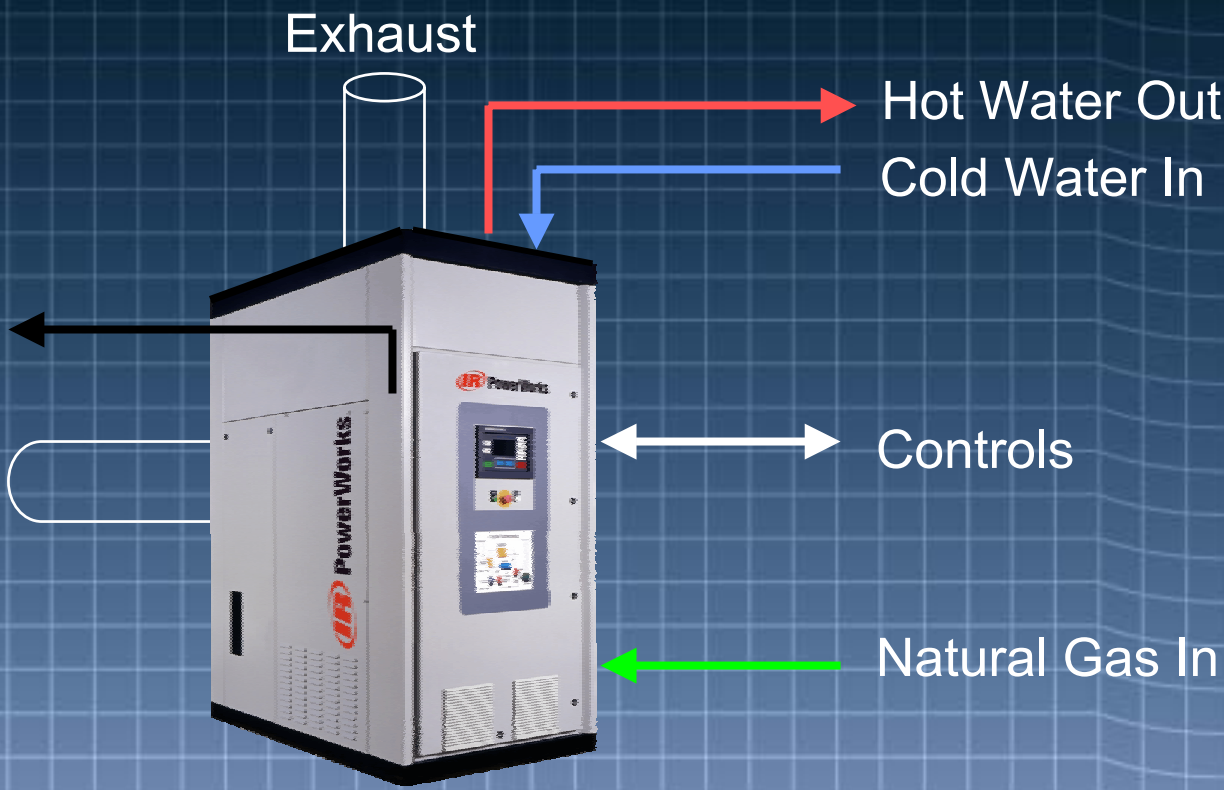
- Uniform Mechanical Code
- National Fuel Gas Code ANSI 2223.1/NFPA 54
- NFPA 37 – Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
- UL2200 – Stationary Engine Generator Assemblies

Also (where applicable):

- UL1741 - Power Converters / Inverters
- Existing Interconnect Standards
  - NY: PSC SIR
  - CA: Rule 21
  - Future? IEEE SCC21 P1547 National Interconnect

Facility-Microturbine Integration

Physical Layout



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Typical Indoor Installation

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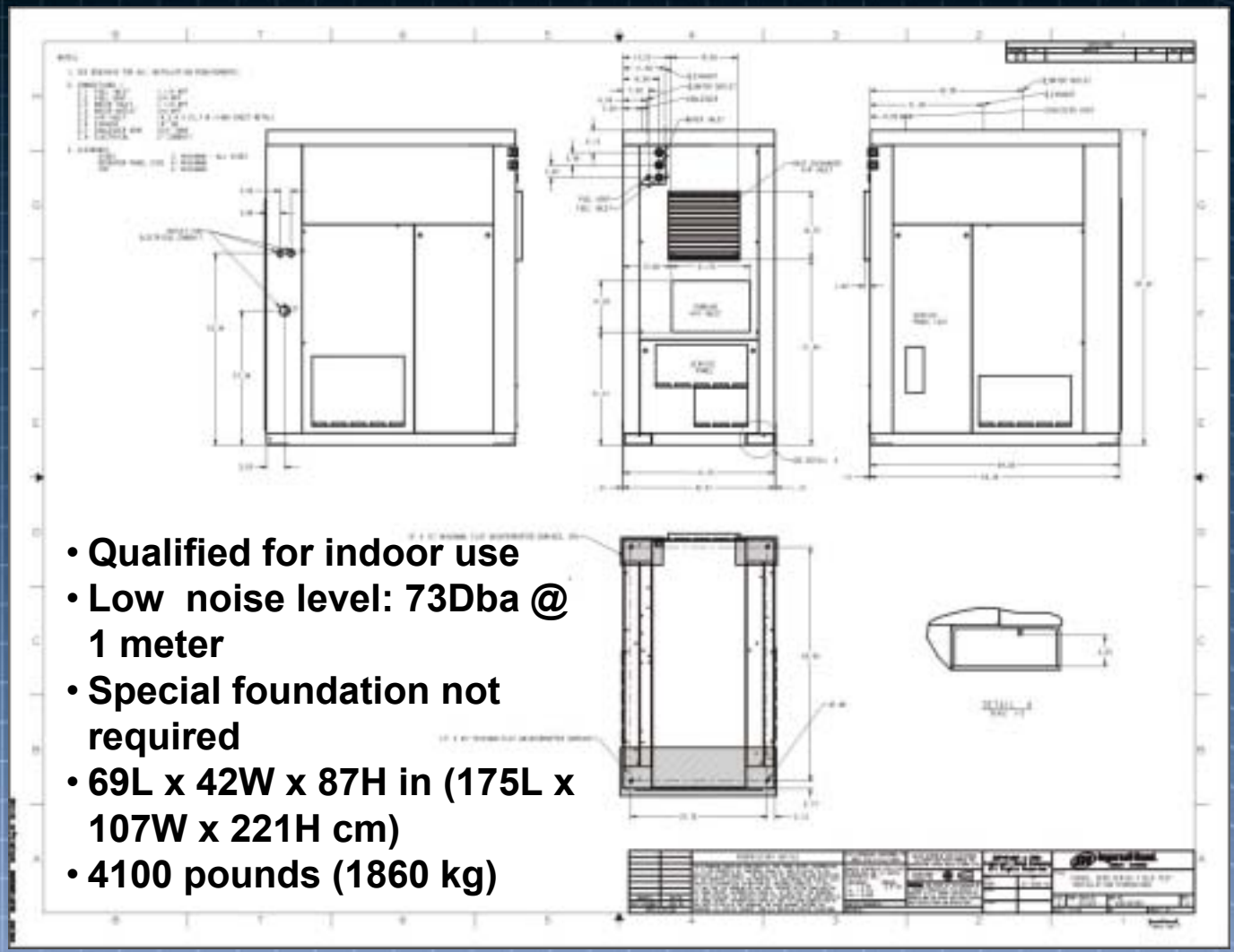
Compact Footprint Enclosure



- Qualified for indoor use
- Low noise level: 73Dba @ 1 meter
- Special foundation not required
- 69L x 42W x 87H in (175L x 107W x 221H cm)
- 4100 pounds (1860 kg)

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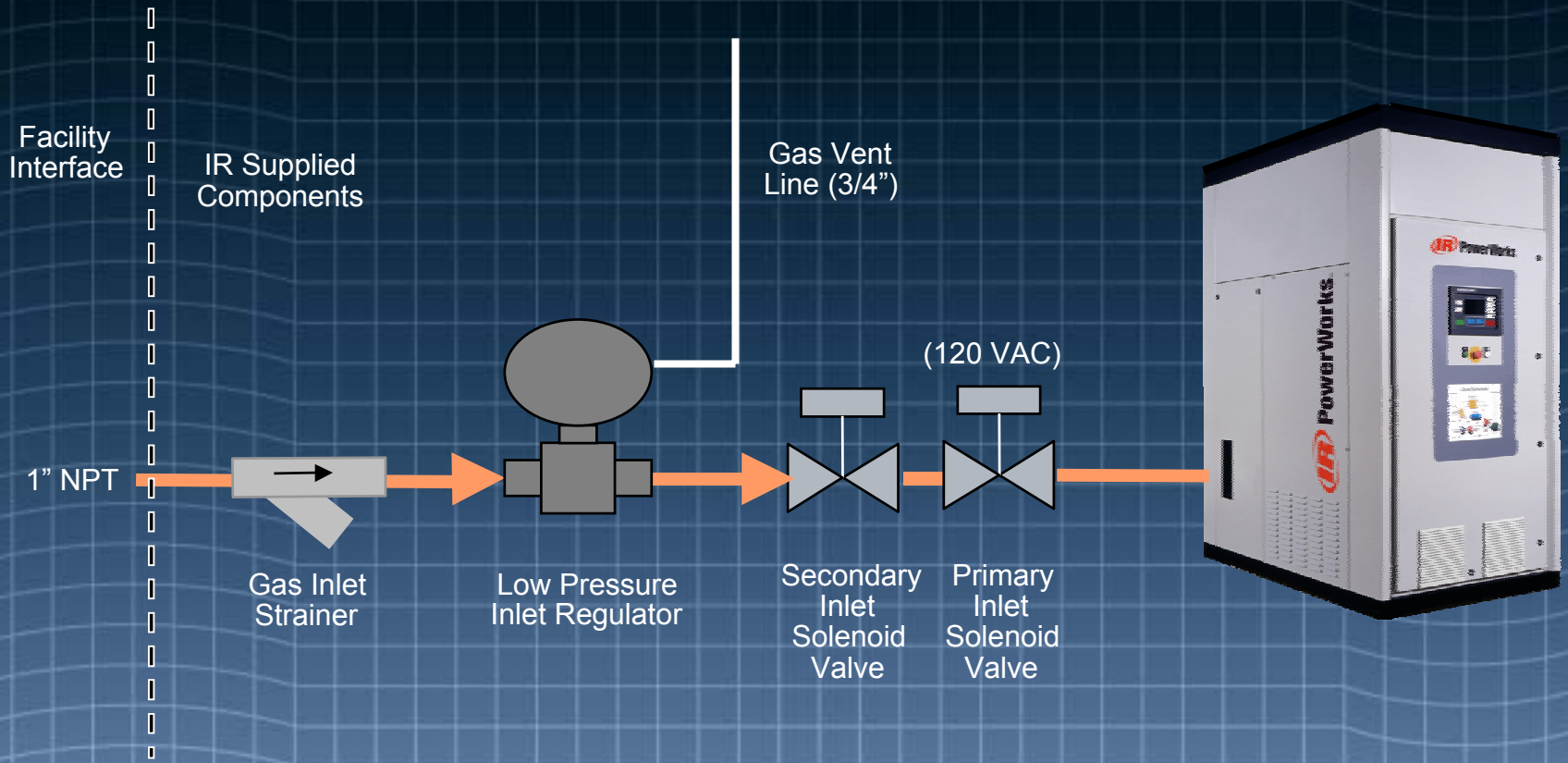
Natural Gas Input



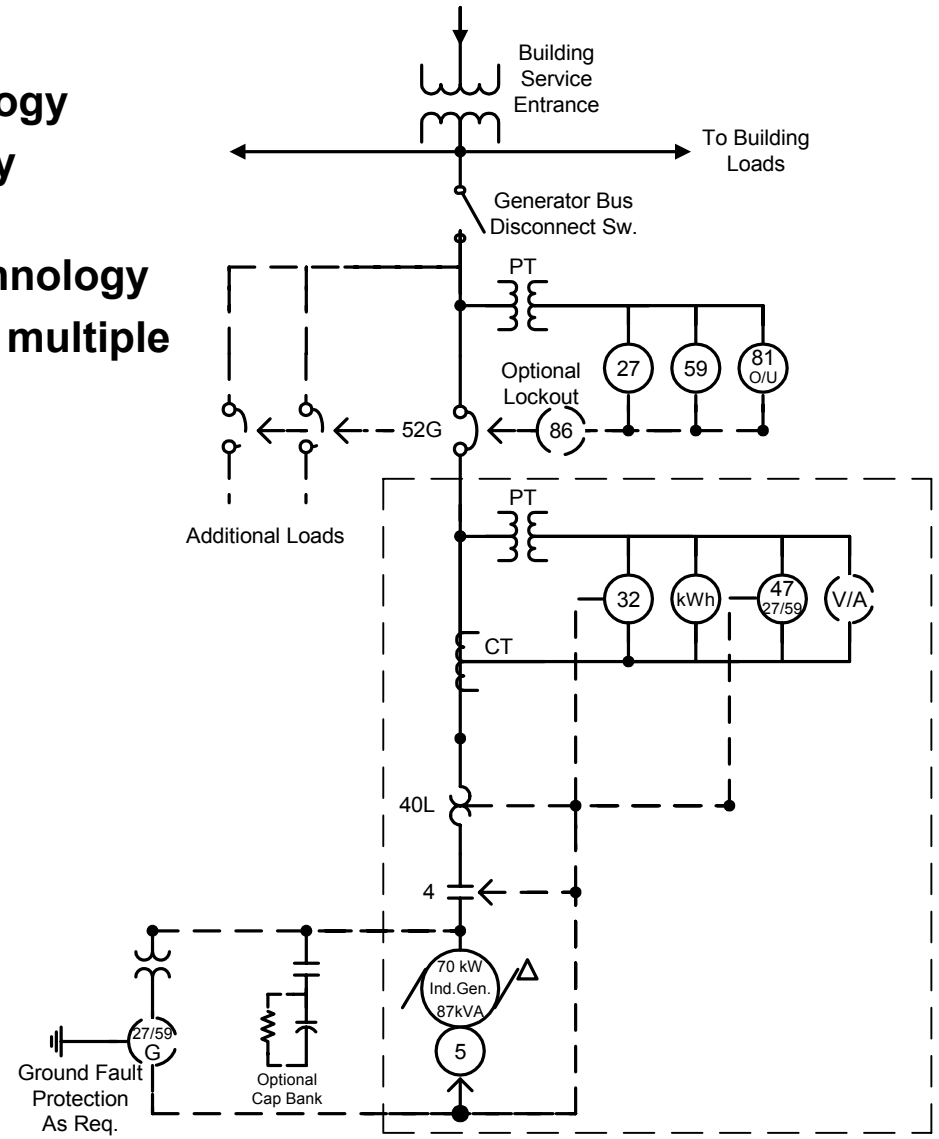
- **Sealed fuel handling system**
- **Minimum inlet pipe pressure = 0.29 PSIG**
- **Minimum flow = 52.9 lbm/hr**

Basic Induction Generator Configuration

- **Industry standard generator technology**
- **Well understood by utilities**
- **Clean, reliable technology**
- **Easily operated as multiple units**

Key:

Device Number	Definition
4	Master Contactor
40L	Contactor Overload
5	Stopping Device
27	Undervoltage Relay
27/59 G	Ground Overvoltage
32	Reverse Power Relay
47	Phase Sequence
59	Overvoltage Relay
81 O/U	Over/Under Frequency
86	Lockout Relay



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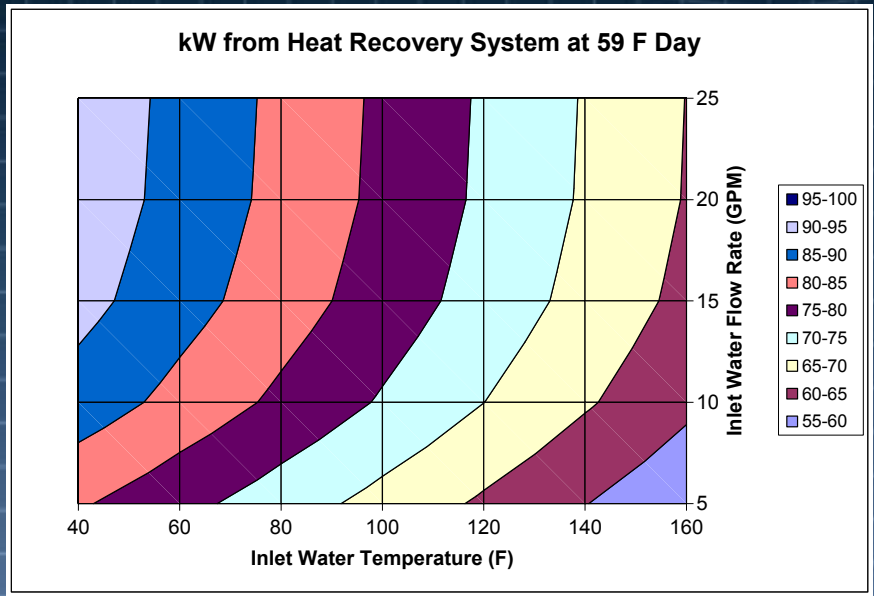
Directly Integrated Heat Recovery System

- Built into exhaust plenum immediately after recuperator
- Designed for heating water
  - 6 to 26 gpm
  - Up to 200°F water output
  - Suitable for potable water up to 125 psig
  - Example: 273,000 BTU/hr @ 20GPM with inlet water temperature of 150ºF



- Heat can also be recovered directly from exhaust
  - About 400°F after recuperator
  - Very low emissions, perhaps cleaner than air input!

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Air / Exhaust Handling

- Independent inlet air ducting
  - 1100 scfm typical
  - Cool, filtered air preferred
  - Max duct pressure loss = 0.25” H2O
- Exhaust
  - Dry, low-NOx technology
  - NOx: <9 ppmv @15% O2
    <0.045 lbm/hr (<20 gm/hr)
  - CO: <9 ppmv @15% O2
    <0.045 lbm/hr (<20 gm/hr)
  - Max duct pressure loss = 0.75” H2O

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Built-In Industrial Controls

- Industrial pedigree
- Serial communications interface
- Discrete control interface
  - Automatic start-stop
  - Facility fault input
  - Remote emergency stop
- Ready to be integrated into building Energy Management System (EMS)